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MODEL 611 CARDIOID UNIT

OPERATION & SERVICE MANUAL

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AUSTIN, TEXAS

TRACOR INC.

TRACOR INC.

SUPPLEMENT B (for S/N 053)

DATE 7-15-65

MANUAL CHANGES

MODEL 611 CARDIOID UNIT
December 1964

CARDIOID UNIT MODIFICATIONS (For use with Model 599-800 Whip Antenna)

Serial No. 053 Cardioid Unit is modified for use with the Model 599-600 Loop Antenna and the Model 599-800 Whip Antenna. This modification is necessary due to the large phase variation of the whip antenna with frequency (see Fig. 7-6). The variable phase network in the standard Cardioid Unit does not have sufficient range to compensate for these large phase changes.

A FREQUENCY RANGE switch is added to this unit to select the proper phase shift for a particular group of frequencies. This switch has three positions, as follows:

1. 9 kc to 14 kc
2. 13 kc to 20 kc
3. 19 kc to 30 kc

This switch bypasses the appropriate phase lag network in the loop channel to give the necessary phase shift. With the switch in the 19 kc to 30 kc position no bypassing takes place, so the units perform the same as the standard ones. With the Model 599-800 Whip Antenna used in place of the whip of Fig. 7-3, the FREQUENCY RANGE switch must be set to cover the frequency received.

The gain of the whip channel may be changed to accommodate greater amplitude difference between whip and loop signals as follows: To lower the gain, increase the value of R17 in the emitter of Q5; to raise the gain, decrease the value of R17 (do not go below about 50 ohms).

Technical Reference Control Facility
Network Support Office
Network Engineering & Operations Division

The following Figures apply to the special Cardioid Unit

Fig. 7-5 Schematic, Model 599-800 Whip Antenna.
Amplitude and Phase Response Vs. Frequency for 599-800 Whip, Dwg. No. A752-55.

Fig. 7-6 Amplitude and Phase Response Vs. Frequency for 599-800 Whip, Dwg. No. A752-54.

The following parts have been added to this Cardioid Unit:

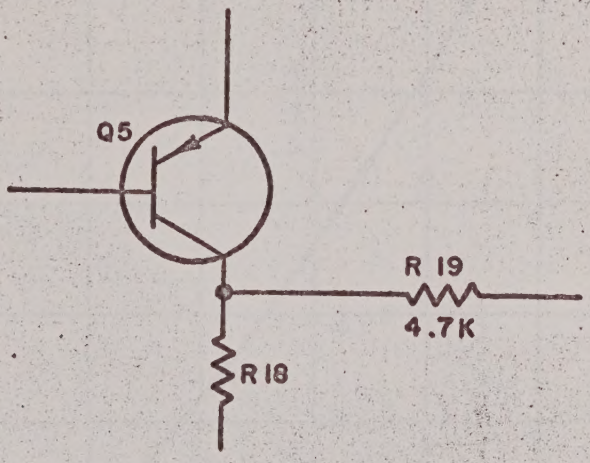
REF	VALUE	DESCRIPTION	VENDOR	PART NO.
S3		Switch, rotary, 1 pole, 3 pos	81073	5-001-3
		Plate, Identification	19397	725024

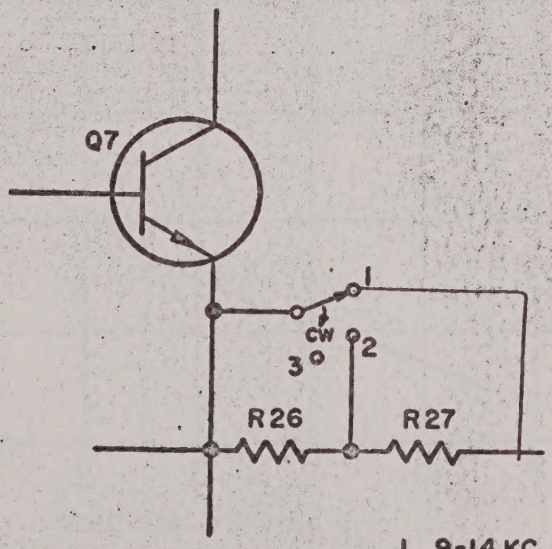
VENDOR CODE

81073 Grayhill Mfg. Co.
19397 TRACOR, Inc.

R19 is changed from 10K to 4.7K Resistor, Fixed Carbon ½W, ± 10%
Vendor 44655

THE FOLLOWING SCHEMATIC CHANGES APPLY FOR S/N 053 ON FIG. 7-2 OF THE BASIC MANUAL.





1. 9-14 KC
2. 13-20 KC
3. 19-30 KC

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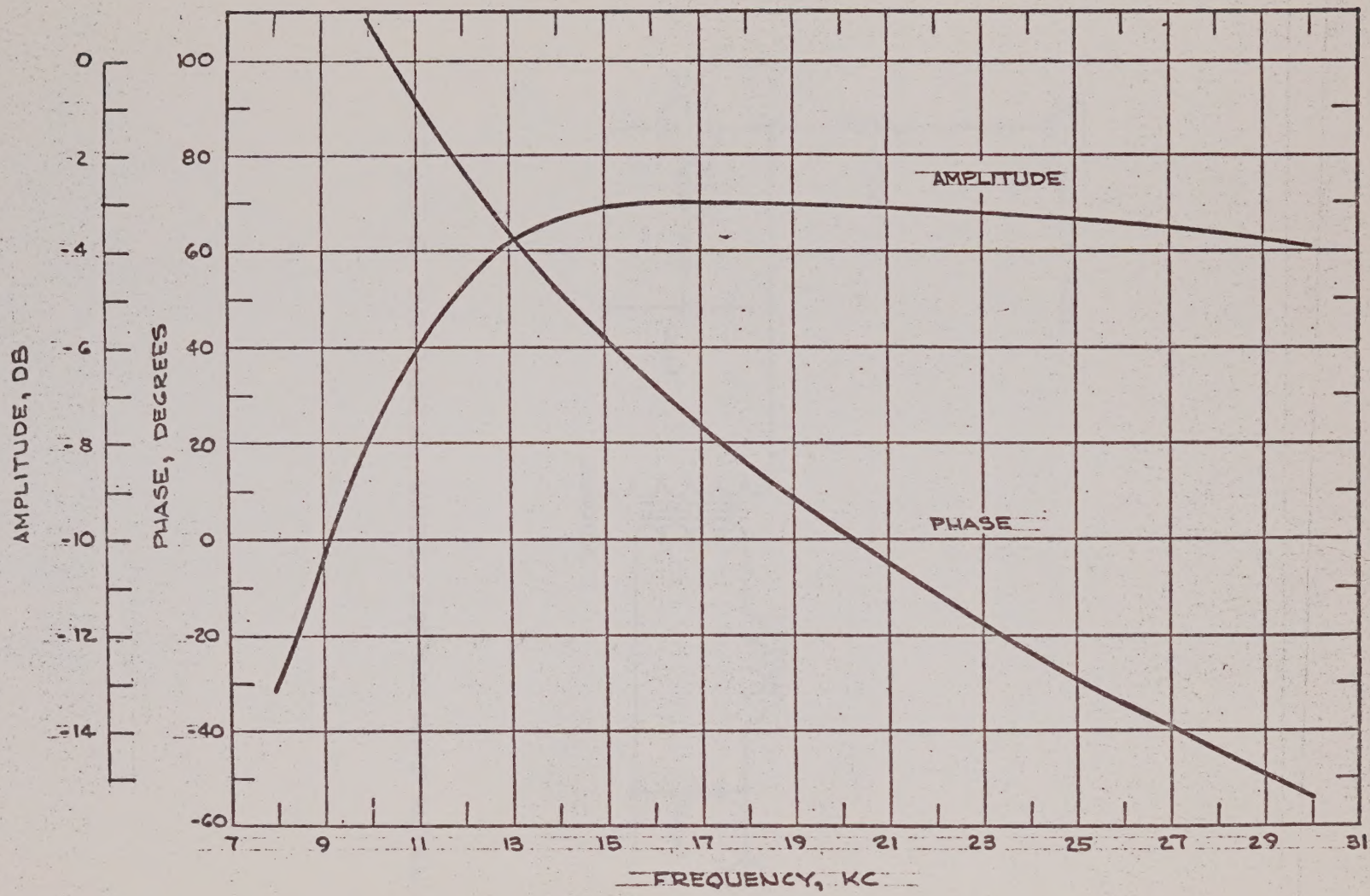
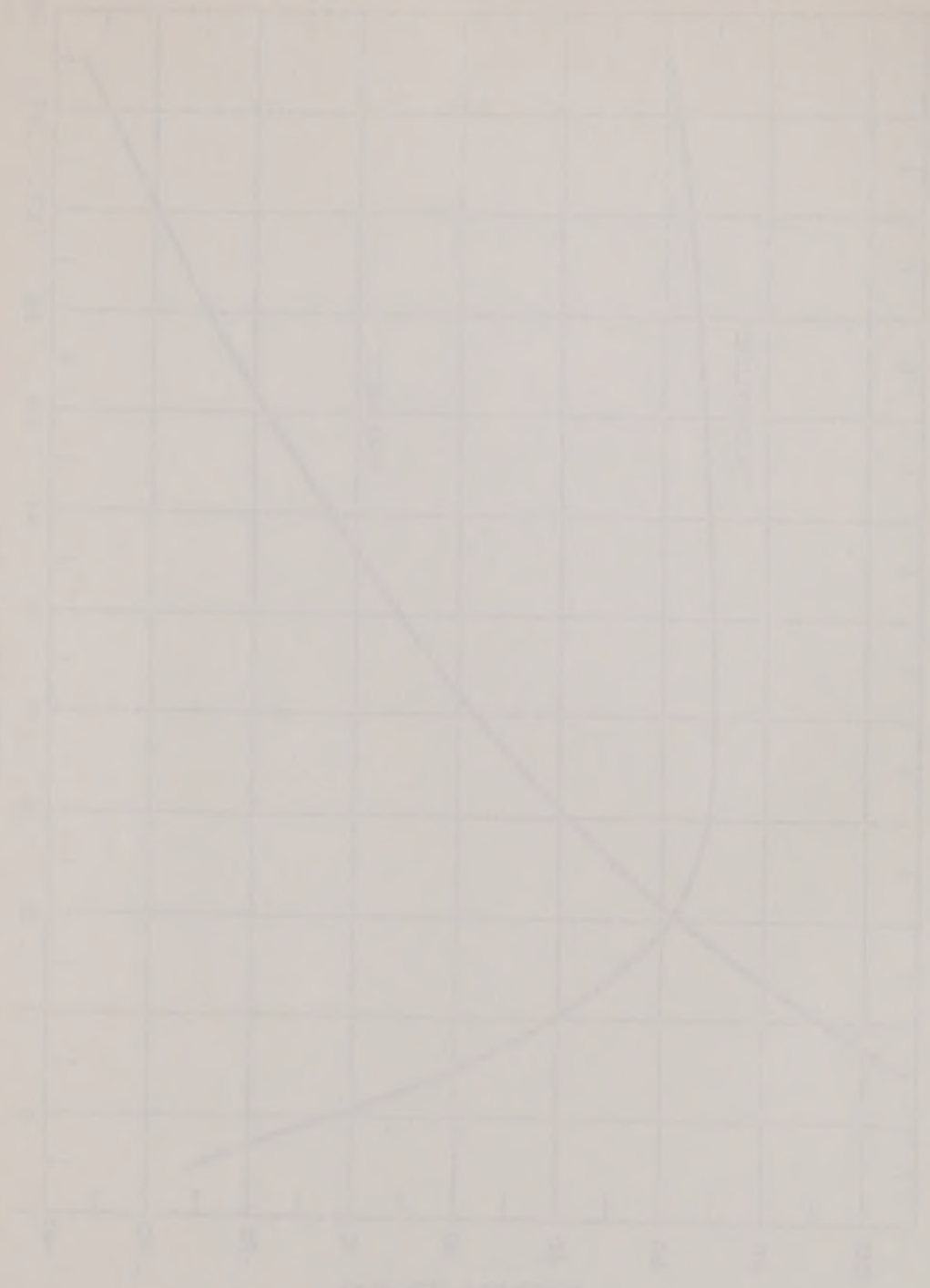


Fig. 7-6 - AMPLITUDE AND PHASE RESPONSE VS. FREQUENCY FOR 599-800 WHIP
(ZERO DB EQUALS GAIN OF 599-600 LOOP AT 20KC.)

TRACOR, INC. AUSTIN, TEXAS 8-25-64 DWG A752-54 FSS/MAP



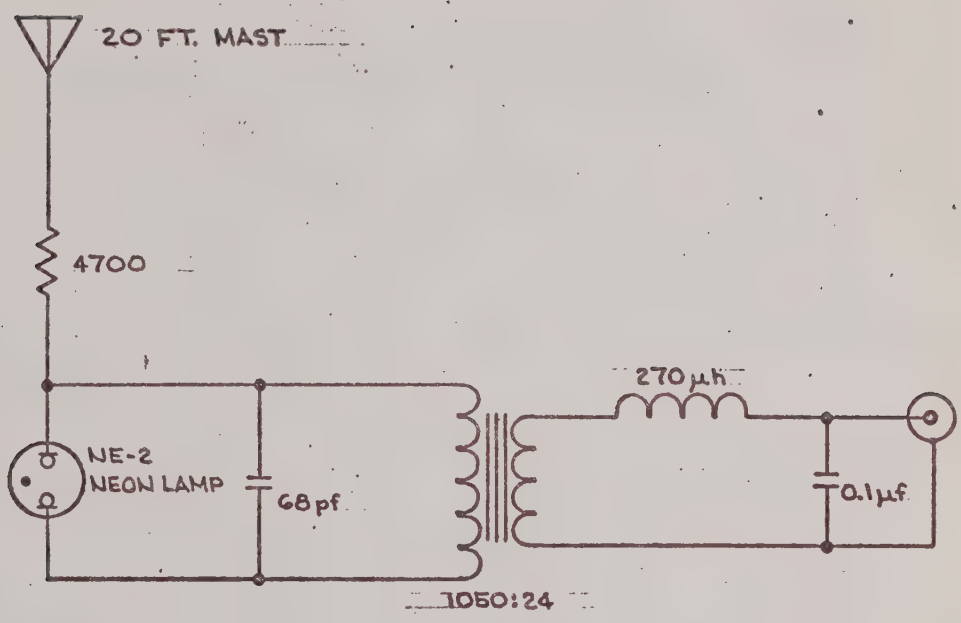


Fig. 7-5 - SCHEMATIC, MODEL 599-800 WHIP ANTENNA

TRACOR, INC. DWG. A752-55
AUSTIN, TEXAS 8-24-64 FSS/MAP

MODEL 611 CARDIOID UNIT

OPERATION & SERVICE MANUAL

December 1964

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WARRANTY

TRACOR, Inc. warrants each instrument it manufactures to be free from defects in material and workmanship. Obligation under this warranty is limited to repairing or replacing any instrument or part thereof that shall be returned to us by the original purchaser, transportation charges prepaid, when upon our examination it is disclosed to our satisfaction to be defective. This warranty is effective for one year after delivery to the original purchaser. If the fault has been caused by misuse or abnormal conditions of operation, repair will be made at cost. In this case, an estimate will be submitted before work is started.

If any fault develops, notify TRACOR, Inc. and give full details, including Model Number and Serial Number. You will then be notified of the disposition of the defective instrument.

TRACOR, Inc.
Manufacturing
WAlnut 60220

6500 Tracor Lane
Austin, Texas
78721

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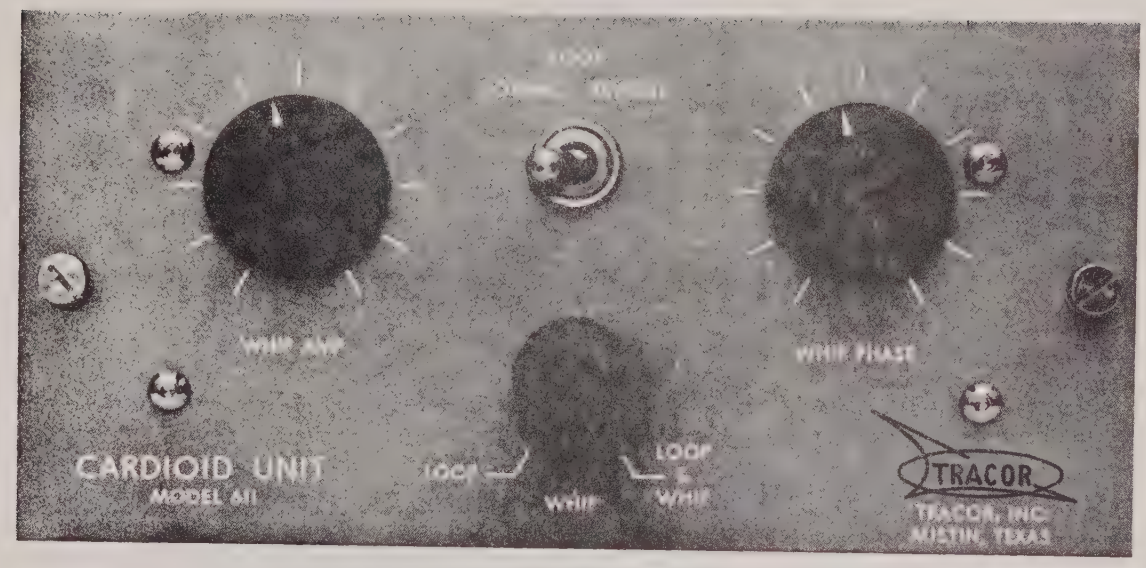
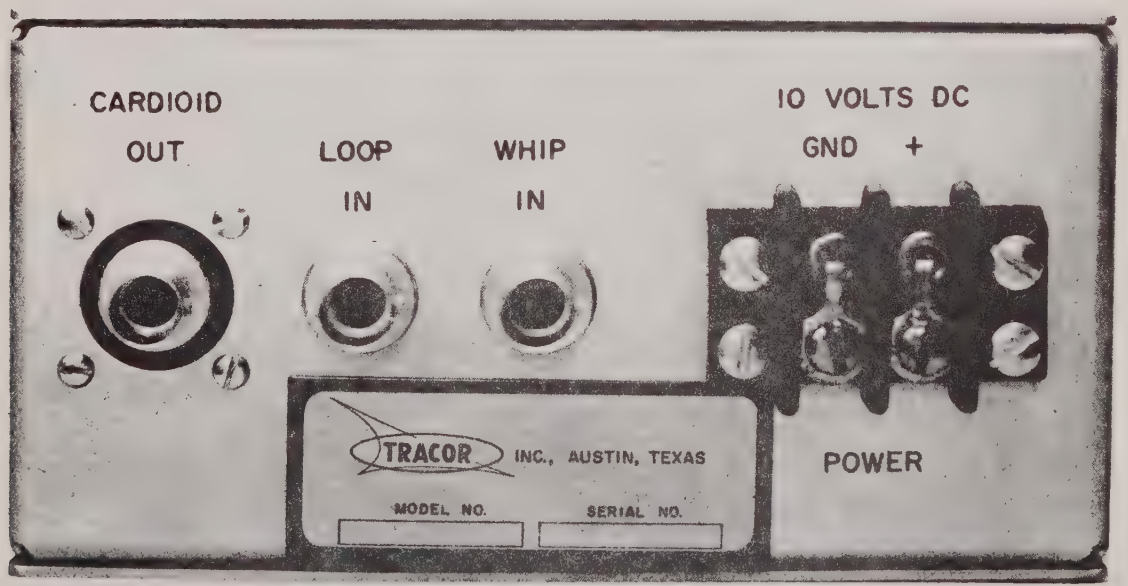


FRONT VIEW



BACK VIEW

CARDIOID UNIT MODEL 611

SECTION 1

INTRODUCTION

1.1 Purpose and Description

VLF signals can travel tremendous distances with relatively low attenuation. In general, this low attenuation is advantageous in that it permits reliable reception at long range, even with low powered VLF transmitters. Under some conditions, however, the low attenuation can in itself introduce additional problems. Thus, at very long ranges, it is possible to receive significant amounts of VLF energy along both the short great-circle path and long great-circle path between the transmitter and receiver locations. (See figure 1-2.) The presence of VLF energy arriving from these two opposing directions can produce severe disturbances in phase tracking.

The TRACOR® Model 611 Cardioid Unit provides a convenient means for discriminating against either one of these two signal components. Normal phase tracking can then be maintained on the incoming VLF energy from a selected direction.

Four distinct antenna patterns are obtainable from the Model 611 Cardioid Unit. These, as illustrated in figure 1-3, include:

a. loop (figure-of-eight pattern)
b. vertical antenna (omnidirectional pattern)
c. cardioid pattern (normal)
d. cardioid pattern (reverse direction)

Any of these directivity patterns can be selected by means of a front panel switch. The cardioid antenna pattern is obtained by

T- TRANSMITTER
R - RECEIVER

Figure 1-2. Direct and Around-the-World Transmission Paths for VLF Frequencies

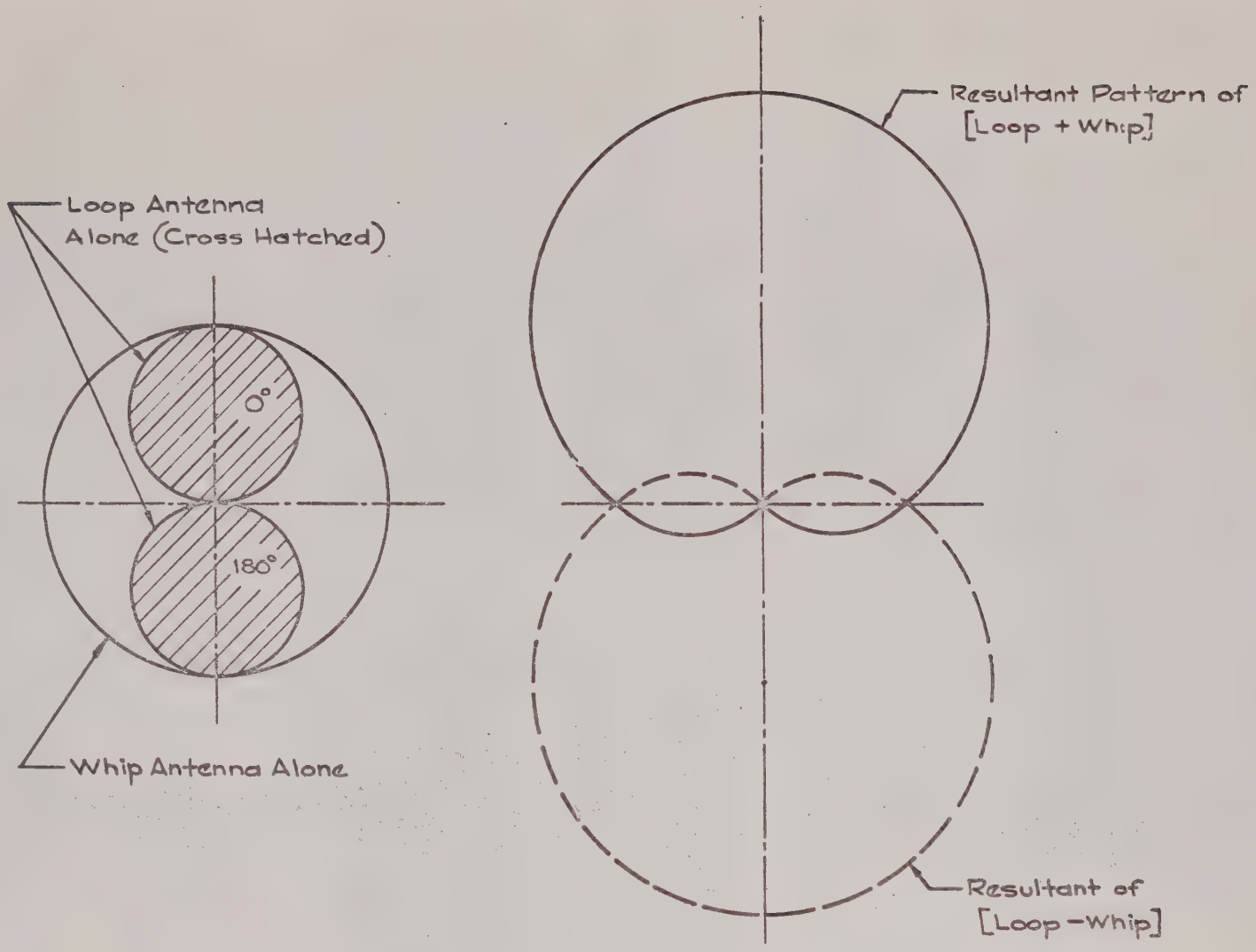


Figure 1-3. Cardioid Pattern (in azimuth) produced by Vector Summation and Vector Difference of Whip and Loop Antennas

vector combination of the signals from a loop antenna and a vertical whip antenna. The Model 611 Cardioid Unit is provided with front panel controls for adjustment of the amplitude and phase of the amplified signal from the whip antenna relative to the loop output. Furthermore, a convenient reversing switch permits electrical reversing of the cardioid pattern without physical rotation or re-orientation of the antenna system. The cardioid patterns derived in this fashion can have a front-to-back discrimination ratio in excess of 30 db.

The transistorized Model 611 Cardioid Unit operates from any regulated +10 volt supply; the +10 volt regulated output available from the TRACOR Series 599 VLF Tracking Receiver is recommended for this purpose. (A separate d-c supply of + 10.5 to + 15 volts may be used if C12 is replaced by a zener diode. See TRACOR drawing 725019 in Section 7).

The Model 611 Cardioid Unit is specifically designed for use with the TRACOR Model 599-600 Loop Antenna and a special 20 ft. vertical whip antenna; however, with minor modification in the Cardioid Unit, it should be possible to achieve similar cardioid pattern discrimination with other standard antennas.

The output of the Cardioid Unit is matched to the TRACOR Series 599 receiver input and there is no degradation of receiver performance through the use of this auxiliary unit.

1.2 Specifications

Power Requirements	10 volts regulated dc; 9 ma current drain. (With CR1 installed in place of C12: 10.5 volts d-c, 15 ma (min) 12.0 volts d-c, 32 ma (nom) 15.0 volts d-c, 60 ma (max)
Antenna Input Requirements	Designed for use with TRACOR Model 599-600 loop antenna or equivalent and whip antenna as described in Section 4.2 and figure 7-3
Input Impedance	50 ohms, both inputs
Output Impedance	50 ohms
Loop Signal Gain	0 db nominal
Whip Signal Gain	Adjustable from approximately -7 db to approximately +13 db
Loop Signal Phase Shift	105° lag, nominal, with LOOP switch in NORMAL; 75° lead, nominal, with switch in REVERSE
Whip Signal Phase Shift	Adjustable from approximately -45° to approximately +45°
Antenna patterns Obtainable	a. Loop (figure-of-eight) b. Whip (omnidirectional) c. Cardioid (normal) d. Cardioid (reverse direction)
Dimensions	3-5/16 inches high, 6-7/8 inches wide, 8-1/8 inches deep
Weight	2 pounds
Rack Mounting Panel (Optional)	Mounts two Cardioid Units; panel dimensions, 19 inches wide, 5-3/16 inches high

SECTION 2

INSTALLATION

Installation of the Model 611 Cardioid Unit may be readily accomplished by following the steps outlined below:

A. Carefully unpack the equipment, examine it to insure that damage has not been incurred in transit, and mount it in the desired location.

B. Connect the +10 volt and GND terminals on the rear chassis terminal strip to the +10 volt and GND terminals (J015-7 and J015-16, respectively) of the TRACOR Series 599 Receiver. (Receivers having serial numbers 001 through 116 do not have the +10 volts brought out to J015. Consult TRACOR for modification instructions.)

C. Connect the loop and whip antennas to the LOOP IN and WHIP IN coaxial connectors on the rear of the chassis. Use 50 ohm coaxial cable.

D. Connect the CARDIOID OUT connector to the receiver ANTENNA input connector, using 50 ohm coaxial cable.

The installation is now complete and operation in accordance with Section 3 may begin.

SECTION 3

OPERATION

3.1 Controls and Connectors

LOOP, WHIP, LOOP & WHIP Switch. This switch selects a loop antenna pattern (figure-of-eight) from the Cardioid Unit when it is in the LOOP position, a whip pattern (omnidirectional) when in the WHIP position and a cardiodal pattern when in the LOOP & WHIP position.

LOOP NORMAL/REVERSE Switch. The cardioidal antenna pattern may be reversed by means of this switch.

WHIP AMP Control. The whip signal gain may be adjusted from approximately -7 db to approximately +13 db by means of this control. (This enables gain of whip to be matched to that of loop in the formation of the cardiodal pattern.)

WHIP PHASE Control. The whip phase may be adjusted by means of this control from approximately -45 degrees (fully clockwise) to approximately +45 degrees (fully counterclockwise). (This provides allowance for tuning and manufacturing tolerances in the loop and whip in the formation of the cardioidal pattern.)

LOOP IN Connector. This connector is the point of application of the standard loop antenna such as the TRACOR Model 599-600.

WHIP IN Connector. This connector is the point of application of the omnidirectional whip antenna similar to that described in Section 4.2 and figure 7-3.

CARDIOID OUT Connector. The loop, whip, or cardioid output (as selected by the LOOP, WHIP, LOOP & WHIP switch) is provided at this terminal for connection to the receiver input.

POWER IN Connector. This connector is the point of application of the regulated +10 vdc power required by the Cardioid Unit.

3.2 Operational Procedures

For the purpose of this discussion it is assumed that the Model 611 Cardioid Unit is to be used in conjunction with a standard TRACOR Model 599-600 loop antenna and a 20' vertical antenna having a built-in tuning circuit as described in figure 7-3. Furthermore, it is assumed that the TRACOR Series 599 VLF Tracking Receiver is used and is properly adjusted for tracking a selected VLF frequency. Also, the station selector switches on the base of the vertical antenna and on the loop antenna must correspond to one another and to the selected VLF frequency. Finally, the loop antenna must be oriented so that the direction toward the distant VLF station lies in the loop plane (as indicated by the directional arrow on the nameplate at the base of the Model 599-600 loop antenna).

The procedure for adjustment of the Cardioid Unit controls to produce a cardioid antenna pattern depends upon the location of the receiving station and the strength of the received signal. We can consider, for example, various possible situations, as follows:

Case I: Relatively strong signal reception along both the short great-circle and the long great-circle paths, but with the component from one direction alone being predominant over some time interval each day.

Case II: Weak signal reception along two paths, but with the component from one direction alone known to be predominant over some time interval each day.

Case III: Signals received along short great-circle and long great-circle paths being comparable in amplitude at all times, that is to say, without either component being predominant at any time.

Case IV: Idealized antipode situation in which energy is simultaneously received from nearly all directions.

Case I and Case II are relatively easy to handle and require only that cardioid pattern alignment is made during that particular time of day that one of the two signal components is known to be predominant. Case III and Case IV are much more difficult to handle and require, in general, successive trial-and-error adjustments to achieve any significant degree of discrimination advantage. Fortunately, Case IV can not exist except in a very small region, perhaps 50-100 miles in diameter, in the immediate vicinity of the geographical antipode. Similarly, Case III may be rather rare because of the fact that the customary diurnal changes in VLF signal propagation will markedly favor one or the other of the signal components at certain times during each day. For example, if the propagation path along the short great-circle is in full darkness then, necessarily, the long great-circle path will be in maximum daylight. Attenuation along a day-light transmission path is generally higher than that along a nighttime

path; consequently, the short-great circle path will undoubtedly exhibit a stronger signal level. We can anticipate a 10-20 db variation in relative signal strength between the short great-circle and long great-circle reception components on a daily basis; if we perform the cardioid pattern adjustment at a favorable time of day when a single received signal component predominates, then the discrimination advantage provided by the cardioid pattern itself permits continual phase tracking on this component, even in presence of interference from the other direction.

A step-by-step Cardioid Unit operational procedure will now be given for each of the four operational cases.

Case I: Relatively strong signal reception along both short great-circle and long great-circle paths, but with the component from one direction being predominant over some time interval each day.

If the VLF signal is clearly discernable in the earphones, say, 30 db stronger than the minimum detectable signal level, then the following procedure is recommended.

1) With the LOOP switch of the Cardioid Unit in the NORMAL position, the selector switch in the LOOP & WHIP position, and the WHIP PHASE control approximately centered, adjust the WHIP AMP control for an audio null. If a null cannot be achieved, place the LOOP switch in the REVERSE position and repeat.

2) Adjust the WHIP PHASE control to improve the null. Because the WHIP PHASE adjustment also affects the signal amplitude slightly, it may be possible to improve the null further by readjusting the WHIP AMP control after each adjustment of the WHIP PHASE control.

3) If the null has been obtained with the LOOP switch in the NORMAL position, the maximum of the cardioid is in the direction of the output connector on the 599-600 loop; if the LOOP switch is in the REVERSE position, the null of the pattern is in the direction of the output connector. The cardioid pattern can now be reversed merely by reversing LOOP switch. (We will here adopt the convention that the NORMAL setting orients the cardioid maximum toward the VLF transmitter along the shorter great-circle propagation path.)

4) Verification of proper adjustment of the Cardioid Unit should be made by obtaining phase tracking records over a 24-hour interval. If the signal energyfrom the undesired direction has indeed been eliminated by the cardioid pattern, the phase tracking record will show a diurnal pattern which is representative of VLF energy being received from a single direction. Characteristics of this diurnal pattern include: an increase in path delay (phase delay) when the assumed propagation path is in full darkness; a relative uniformity in phase tracking record and an absence of any deep interference effects during all-daylight condition along the assumed propagation path; and a smooth, nearly sinusoidal pattern on a 24-hour cyclic basis (except for isolated cases of north-south propagation paths in which the transmitter

and receiver locations are both located in the equatorial zone). Presence of an interfering signal, on the other hand, will give rise to erratic phase and amplitude fluctuations which can not be readily interpreted on the basis of a single received component.

Case II: Weak signal reception along two paths, but with the component from one direction known to be predominant during some particular time interval.

The procedure in this case broadly follows that given for Case I with the exception that the desired cardioid null position must be located by means of the receiver meter readings rather than by earphone monitoring of the received VLF signal. Both the MICROSECONDS digital counter and the CARRIER LEVEL meter readings are used to improve the detection capability on a weak signal. Also, as in Case I, an optimum time to make the cardioid adjustments should be found, taking into account the fact that the relative amplitude of the two signals may shift considerably during a 24-hour period. The best time to make the cardioid adjustment must be determined experimentally. The interval when the undesired path is in maximum daylight,

and therefore undergoing maximum attenuation, should receive special attention. The actual adjustment procedure is outlined below.

1) With the selector switch in the LOOP mode of operation and with the loop switch in the NORMAL position, adjust the receiver gain for roughly +10 db reading on the CARRIER LEVEL meter. Note and record the MICROSECOND dial reading during normal phase tracking. (Because of the long time constants in the tracking receiver, sufficient time must be allowed to assure stabilized amplitude and phase readings.)

2) Place the selector switch in the WHIP mode and adjust the WHIP AMP control for the same CARRIER LEVEL reading as above. Adjust the WHIP PHASE for the same MICROSECOND dial reading noted above. (If stable phase tracking is not obtainable at this dial reading, place the LOOP switch in the REVERSE position and repeat the above two steps.) The WHIP PHASE adjustment may influence the CARRIER LEVEL reading; accordingly, it may be necessary to make trimming adjustments to both the WHIP AMP and WHIP PHASE so that the same meter readings are obtained as in the above step.

3) Place the selector switch in the LOOP & WHIP mode. The CARRIER LEVEL meter now indicates the cardioid maximum determined by the LOOP switch (NORMAL or REVERSE) and the orientation of the loop antenna, as described in paragraph 3 of Case I.

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4) Assume that the LOOP switch is in the NORMAL position. Switching to REVERSE should then give the null orientation, as will be noted by a large drop in CARRIER LEVEL reading. It may be possible to improve this null by trial-and-error adjustments of the WHIP AMP and WHIP PHASE controls. The quality of the cardioid null may be estimated by noting the difference (in db) of the CARRIER LEVEL readings in either the WHIP only (or LOOP only) positions and the LOOP & WHIP position. However, it must also be noted that the actual null may be somewhat better than that indicated on the CARRIER LEVEL reading. Some residual reading may be due to coherent signals from other directions or local coherent noise.

5) Verification of proper adjustment of the cardioid pattern should be made by phase tracking observations over a 24-hour period, as explained in paragraph 4 under Case I.

Case III: Signals received along short great-circle and long great-circle paths comparable in magnitude at all times.

If the incoming signals from opposite directions persistently differ by less than ±10 db it is not possible to prescribe a systematic procedure for accurate alignment

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of the cardioid pattern. True, it may be possible to determine a setting which will give a null or minimum on the composite signal from the two directions; however, this does not necessarily ensure that a cardioid-type antenna pattern thereby exists at that time. It therefore becomes necessary that an essentially trial-and-error technique be used to obtain any significant degree of cardioid discrimination. The following general procedure is suggested.

1) Phase tracking and amplitude recordings over several 24-hour intervals should be obtained in either a LOOP or WHIP mode of operation. Observation of these records may indicate that time of day when a particular signal component may predominate (based on a phase change pattern that agrees with that expected for VLF propagation over a particular path and the apparent absence of interference effects in the amplitude pattern during the same time interval.)

2) During the time of day that the interference effects appear to be a minimum, the selector switch should be turned to the NORMAL position and the WHIP PHASE and WHIP AMP controls adjusted, as described previously, for a maximum in the LOOP & WHIP resultant signal. The settings of the WHIP PHASE and WHIP AMP controls should be recorded; these settings are the starting point for further adjustments to obtain improved discrimination.

3) Phase and amplitude recordings should be continued in the LOOP & WHIP mode of operation. Small, systematic adjustments should be made daily to the Model 611 Cardioid Unit, alternating between the WHIP AMP and WHIP PHASE controls, until the observed phase tracking record agrees with the diurnal pattern which would be expected at that particular receiving location for VLF signals received from the chosen direction.

4) After proper settings of the WHIP PHASE and WHIP AMP controls have thus been tentatively established, it is desirable that similar LOOP & WHIP tracking records be obtained over one or more days with the LOOP switch in the REVERSE position. The phase tracking record for the reversed cardioid pattern should obviously agree with that expected from VLF signals arriving from the opposite direction.

Case IV: Idealized antipode situation with significant signal components being received from numerous directions.

We must again resort to trial-and-error methods, as in Case III, if we wish to obtain cardioid pattern discrimination.

SECTION 4

THEORY OF OPERATION

4.1 System Operational Theory

A block diagram of the Model 611 Cardioid Unit is shown in figure 7-1. The unit is shown connected to a TRACOR Model 599-600 loop antenna, a whip antenna as described in figure 7-3, and to the TRACOR Series 599 Receiver as it would be normally used.

A front panel LOOP switch is provided so that the loop signal can be reversed in phase if it is so desired. The loop signal is amplified and passed through a fixed phase shift network which effects a phase lag of approximately 105° at 18 KC, 93° at 14.7 KC, and 117° at 22.3 KC. This is approximate compensation for the phase lag introduced in the signal from the whip because of impedance matching. The phase-shifted loop signal is then fed to a selector switch and to a network for summing with the whip signal. The over-all gain of the loop signal path is approximately 0 db.

The whip signal is fed to an amplifier identical to the one in the loop signal path. The whip signal amplifier output is passed through a variable phase shift network. This network provides for a phase shift range of approximately -45° to +45° at 18 KC by means of the front panel WHIP PHASE adjustment. At 14.7 KC the range of adjustment is approximately -39° to +51°; at 22.3 KC it is approximately -51° to +39°. This range of adjustment is sufficient to compensate for the loop signal phase shift differences at the various VLF frequencies from 14.7 KC to 22.3 KC and phase differences in both antennas due to manufacturing tolerances.

An additional amplifier, plus an amplitude control, is provided in the whip signal path to provide for amplitude differences between the loop and whip. Whip amplitude is controlled by means of the front panel WHIP AMP control. The whip signal is fed to a selector switch and then to a network for summing with the loop signal.

The front panel selector switch has three positions labeled LOOP, WHIP, and LOOP & WHIP. These enable the operator to select the mode of operation desired; that is, loop only, whip only, or loop and whip. In the LOOP & WHIP position the loop and whip signals are summed to produce the desired cardioid pattern. However, in order to produce a good cardioid pattern, it is necessary to have the WHIP PHASE and WHIP AMP controls properly adjusted. Instructions for making these adjustments and for determining the proper setting of the NORMAL-REVERSE switch are found in Section 3.2 of this manual.

4.2 Component Operational Theory

Figure 7-2 (Drawing 725017) is a schematic diagram of the Model 611 Cardioid Unit and figure 7-3 is a schematic diagram of the whip antenna circuit with which the Cardioid Unit is used. Because the whip with its tuning and matching circuits is essential to the proper operation of the Cardioid Unit, it must be included in the description of the Cardioid Unit.

Because of the high output impedance of the 20 ft. whip antenna, it is desirable to transform the impedance to a lower level so that the signal may be matched to the characteristic impedance of a coaxial cable. In addition, it is desirable to tune the antenna to the frequency being received, preferably with the same Q used in the loop tuning circuits.

The signal induced in the whip (figure 7-3) is fed to a parallel resonant circuit consisting of L1, C1, a capacitor selected with the station selector switch S1, and the Cardioid Unit load at J1. L1 has a Q of approximately 100 in the frequency range of interest here. C1 through C9 are precision silvered mica capacitors. R1 in parallel with the tuned circuit lowers the over-all Q to approximately 18 to match the Q of the loop. In switch position 1, R2 is included in the resonant circuit to lower the Q to approximately 5 for broadband operation with the center frequency at 18 KC. R3, R4 and J2 provide for a convenient means of remotely testing the tuning and Q of the circuits. This can be done by injecting signal into J2 from a remote oscillator. The loop cable can be used for this test. R4 provides isolation between the source and the tuned circuit. R3 and R4 form a voltage divider for the input signal and R3 is small enough so that the tuning and Q of the circuit are not disturbed. The test signal output may then be observed at the remote location on an oscilloscope. It is necessary, however, to terminate the cable at the oscilloscope with a 50 ohm load. The most realistic load, of course, is the whip input of the Cardioid Unit itself.

In normal operation the VLF signal from the whip is coupled into the Cardioid Unit through J1 (figure 7-2) with transformer T2 which matches the 50 ohm impedance to the input of the amplifier Q1. Q2 is an emitter follower which provides some negative feedback to Q1 through R2 and a low impedance output to the phase shift circuits.

The variable phase shift circuit consists essentially of R6, C4, C3, R7, Q3, Q4, and R14. R6 and C4 provide approximately 45° of lag and C3 and R7 provide approximately 45° of lead in the frequency range of interest. Q3 and Q4 are emitter followers which provide a low impedance output to the whip phase control, R14. With R14 centered, the phase shift is

approximately zero, but as the control is moved clockwise the phase lag from Q3 predominates over the phase lead from Q4. When the extreme clockwise position is reached, virtually all of the output is from Q3 and virtually none from Q4; thus, the phase shift is -45°. In the same manner, when the control is moved counterclockwise, phase lead from Q4 predominates. A total phase shift of 90° is thus achieved when the control is moved from one extreme to the other. This amount of adjustment is provided so that compensation can be made for loop and whip signal phase differences due to tuning and manufacturing tolerances.

Q5 provides additional amplification for the whip signal so that with the WHIP AMP control, R20, the whip signal amplitude can nominally be varied from +10 db to -10 db with respect to the loop signal amplitude. From R20 the signal is fed to the selector switch S2.

The loop signal enters at J2 and is fed to the LOOP switch S1. It is then coupled to amplifier Q6 through impedance-matching transformer T2. The amplifier and emitter follower consisting of Q5 and Q6, respectively, are identical to the amplifier and emitter follower consisting of Q1 and Q2, respectively. R26, C10, R27, and C11 constitute a phase lag network which provides a phase lag of approximately 105° to compensate for the nominal phase lag in the whip antenna circuits.

Q8 is an emitter follower which provides a high input impedance to the signal from the phase-shift network and a low output impedance for the output signal. This signal is then fed through R29 to selector switch S2.

Switch S2 can select either the whip or loop signal or it can sum the two into the load provided by R30 and the primary of output transformer T3. T3 is an isolating and matching transformer which couples the output signal through J3 and a 50 ohm coaxial cable to the ANTENNA input of the Series 599 Receiver.

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SECTION 5

MAINTENANCE

This section contains two tables designed to aid the maintenance technician in the repair of the Cardioid Unit. The first, table 5-1, is a trouble-shooting chart intended to aid in the isolation of the trouble. It was assumed in the preparation of this table that both the whip and loop antennas were properly tuned to a station known to be broadcasting and that the loop was oriented properly. A voltage chart, table 5-2, is also included to aid in trouble-shooting.

The Cardioid Unit requires no periodic maintenance.

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Table 5-1. Trouble-Shooting Chart

Symptom	Possible Cause
1. No output when selector switch is in either LOOP, WHIP or LOOP & WHIP position	No +10 volts dc at POWER input terminals Defective transformer T3 Defective switch S2
2. Output present when selector switch is in LOOP position but not when in WHIP position	Defective cable between whip antenna and Cardioid Unit Defective switch S2 Defective transformer T1 Defective transistor Q1, Q2, Q3, Q4 or Q5, or associated components
3. Output present when selector switch is in WHIP position but not in LOOP position	Defective cable between loop antenna and Cardioid Unit Defective switch S2 Defective transformer T2 Defective switch S1 Defective transistor Q6, Q7 or Q8, or associated components
4. Output present when in LOOP or WHIP position but not when in LOOP & WHIP position	Defective switch S2
5. Output present when in LOOP & WHIP position but not when in LOOP or WHIP position	Defective switch S2

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Table 5-1. Trouble-Shooting Chart

Symptom	Possible Cause
6. Output amplitude less when in LOOP position than it is when in WHIP position with WHIP AMP in extreme CCW position	Defective transistor Q6, Q7 or Q8, or associated components
7. Output amplitude greater when in LOOP position than it is when in WHIP position with WHIP AMP in extreme CW position	Defective transistor Q1, Q2, Q3, Q4 or Q5, or associated components
8. Output when in WHIP position can be made equal (with WHIP AMP control) to the output when in LOOP position but cardioid pattern unobtainable in LOOP & WHIP position (with LOOP switch in either NORMAL or REVERSE	Defective transistor Q3 or Q4, or associated components Defective component R26, C10, R27 or C11

Table 5-2a. Voltage Chart

Initial Conditions:

a. For dc measurements, no signal in either input.

b. For ac measurements, 3 mv p-p at 18 kc into WHIP IN input.

c. WHIP PHASE and WHIP AMP controls centered.

d. Selector switch in WHIP position.

e. Measurements at all test points except Y are made with respect to G (circuit ground); measurement at Y is made with respect to point Z.

f. CARDIOID OUT connector is unterminated.

g. Volts DC in parentheses are for 12 VDC input to power strip for unit using CR1 in place of C12.

Test Point	Volts DC	Peak-to-Peak Volts AC
A	0	0.003
B	0.6	0.006
D	0.6	0.003
E	9.5 (8.4)	0.005
F	5 (3.5)	0.8
H	4.5 (3.4)	0.8
I	4.5 (3.4)	0.55
J	0	0.55
K	5 (4.3)	0.55
L	5 (4.3)	0.55
M	4.8 (4.2)	0.55
O	4.8 (4.2)	0.55
Q	4.8 (4.2)	0.34
R	9.5 (8.6)	0.34
S	1 (1.1)	1.75
T	0.8	1.4
U	0	0.022
Y	0	0.005

Table 5-2b. Voltage Chart

Initial Conditions:

a. For dc measurements, no signal into either input.

b. For ac measurements 3 mv p-p at 18 kc into LOOP IN input.

c. Selector switch in LOOP position.

d. Measurements at all test points except Y are made with respect to G (circuit ground); measurement at Y is made with respect to point Z.

e. CARDIOID OUT connector is unterminated.

f. LOOP switch in NORMAL position.

g. Volts DC in parentheses are for 12 VDC input to power strip for unit using CR1 in place of C12.

Test Point	Volts DC	Peak-to-Peak Volts AC
AA	0	0.003
CC	0.6	0.006
EE	0.6	0.003
FF	5 (3.9)	0.8
HH	4.5 (3.6)	0.8
II	9.5 (8.3)	0.005
JJ	4.5 (3.6)	0.45
KK	4 (3.5)	0.23
LL	4 (3.5)	0.23
MM	0	0.025
U	0	0.025
Y	0	0.005

SECTION 6

TABLE OF REPLACEABLE PARTS

Table 6-1 lists all replaceable parts of the Cardioid Unit except minor items of hardware.

To order a replacement part, address order or inquiry either to your authorized TRACOR, Inc. Sales Representative or to:

Customer Service
TRACOR, Inc.
6500 Tracor Lane
Austin, Texas 78721

Specify the reference designator, value and description of each part. To order a part not listed, describe as fully as possible its function and location. Part numbers as shown in Table 6-1 may change as vendor items are re-evaluated or as improved components become available. The equivalent component used in current production at the time the order is received will be shipped.

Part manufacturers and their part numbers are given for convenience of the purchaser in ordering replacement parts from local supply sources. Manufacturers are referred to in the fourth column by a vendor code, the key to which is given below.

Vendor Code

01295	Texas Instruments, Inc., Dallas, Texas
02735	Radio Corporation of America, Semiconductor and Materials Division, Somerville, New Jersey
04099	Capco Corp., Cleveland, Ohio
44655	Ohmite Mfg. Company, Skokie, Illinois
56289	Sprague Electric Company, Des Plaines, Illinois
71590	Centralab Division of Globe-Union, Inc., Milwaukee, Wisconsin
71785	Cinch Mfg. Co., Division of United-Carr Fastener Corp., Chicago, Illinois

72653	GC Electronics Mfg. Company, Rockford, Illinois
90095	Technitrol Engineering Co., Philadelphia, Pa.
91737	Gremar Mfg. Company, Inc., Wakefield, Mass.

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Table 6-1. Table of Replaceable Parts

REF	VALUE	DESCRIPTION	VENDOR	PART NUMBER
C1	10mfd	Capacitor Electrolytic, Aluminum 15 vdcw -10 to 100%	56289	TE1155
C2	10mfd	Capacitor Electrolytic, Aluminum 15 vdcw -10 to 100%	56289	TE1155
C3	0.01mfd	Capacitor Mylar Film, 200 vdcw ±5%	04099	MW10325
C4	0.01mfd	Capacitor Mylar Film, 200 vdcw ±5%	04099	MW10325
C5	0.1mfd	Capacitor Disc Ceramic, 10 vdcw -0 to 100%	56289	HY-320
C6	0.1mfd	Capacitor Disc Ceramic, 10 vdcw -0 to 100%	56289	HY-320
C7	0.1mfd	Capacitor Disc Ceramic, 10 vdcw -0 to 100%	56289	HY-320
C8	10mfd	Capacitor Electrolytic, Aluminum, 15 vdcw, -10 to 100%	56289	TE1155
C9	10mfd	Capacitor Electrolytic, Aluminum, 15 vdcw, -10 to 100%	56289	TE1155
C10	0.01mfd	Capacitor Mylar Film, 200 vdcw ±5%	04099	MW10325
C11	0.0015 mfd	Capacitor Mylar Film, 200 vdcw ±5%	04099	MW15225
CR12	10 mfd	Capacitor Electrolytic, Aluminum, vdcw, -10 to 100%	56289	TE1155
CR1		Diode, Zener, 9.1 volts	01295	1N3019B
J1		Connector BNC Panel	91737	UG657/U
J2		Connector BNC Panel	91737	UG657/U
J3		Connector BNC Panel	91737	UG657/U
Q1		Transistor NPN Si	02735	2N2270
Q2		Transistor NPN Ge	01295	2N1304

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Table 6-1. Table of Replaceable Parts (Cont'd)

REF	VALUE	DESCRIPTION	VENDOR	PART NUMBER
Q3		Transistor NPN Ge	01295	2N1304
Q4		Transistor NPN Ge	01295	2N1304
Q5		Transistor PNP Ge	01295	2N1305
Q6		Transistor NPN Si	02735	2N2270
Q7		Transistor NPN Ge	01295	2N1304
Q8		Transistor NPN Ge	01295	2N1304
R1	220Ω	Resistor Fixed Carbon 1/2w ±10%	44655	
R2	22K	Resistor Fixed Carbon 1/2w ±10%	44655	
R3	10K	Resistor Fixed Carbon 1/2w ±10%	44655	
R4	1.5K	Resistor Fixed Carbon 1/2w ±10%	44655	
R5	270Ω	Resistor Fixed Carbon 1/2w ±10%	44655	
R6	1K	Resistor Fixed Carbon 1/2w ±10%	44655	
R7	1K	Resistor Fixed Carbon 1/2w ±10%	44655	
R8	18K	Resistor Fixed Carbon 1/2w ±10%	44655	
R9	18K	Resistor Fixed Carbon 1/2w ±10%	44655	
R10	18K	Resistor Fixed Carbon 1/2w ±10%	44655	
R11	18K	Resistor Fixed Carbon 1/2w ±10%	44655	
R12	10K	Resistor Fixed Carbon 1/2w ±10%	44655	
R13	10K	Resistor Fixed Carbon 1/2w ±10%	44655	
R14	5K	Resistor Variable Comp. 2w ±10%	44655	CU5021
R15	10K	Resistor Fixed Carbon 1/2w ±10%	44655	
R16	220K	Resistor Fixed Carbon 1/2w ±10%	44655	
R17	180Ω	Resistor Fixed Carbon 1/2w ±10%	44655	

Table 6-1. Table of Replaceable Parts (Cont'd)

REF	VALUE	DESCRIPTION	VENDOR	PART NUMBER
R18	1.2K	Resistor Fixed Carbon 1/2w ±10%	44655	
R19	10K	Resistor Fixed Carbon 1/2w ±10%	44655	
R20	100K	Resistor Variable Comp. 2w ±10%	44655	CU1041
R21	220Ω	Resistor Fixed Carbon 1/2w ±10%	44655	
R22	22K	Resistor Fixed Carbon 1/2w ±10%	44655	
R23	10K	Resistor Fixed Carbon 1/2w ±10%	44655	
R24	1.5K	Resistor Fixed Carbon 1/2w ±10%	44655	
R25	270Ω	Resistor Fixed Carbon 1/2w ±10%	44655	
R26	1K	Resistor Fixed Carbon 1/2w ±10%	44655	
R27	10K	Resistor Fixed Carbon 1/2w ±10%	44655	
R28	10K	Resistor Fixed Carbon 1/2w ±10%	44655	
R29	6.8K	Resistor Fixed Carbon 1/2w ±10%	44655	
R30	820Ω	Resistor Fixed Carbon 1/2w ±10%	44655	
R31	100 Ω	Resistor Fixed Carbon 1w ±10%	44655	
S1		Switch, Toggle, Bathandle DPDT	72653	34-182
S2		Switch, Rotary, 2 pole, 6 pos.	71590	PA-2002
T1		Transformer, Pulse, 22 ma, 3:1:1	90095	G3WA
T2		Transformer, Pulse, 22 ma, 3:1:1	90095	G3WA
T3		Transformer, Pulse, 22 ma, 3:1:1	90095	G3WA
TS		Terminal block, 2 terminals	71785	2-141Y

SECTION 7

SCHEMATIC DIAGRAMS

This section contains a block diagram of the Cardioid Unit, a schematic diagram of the Cardioid Unit, and a schematic diagram of a whip antenna used with the cardioid. The schematic of the whip antenna is included because the tuning and matching circuits provided with the whip are essential to the proper operation of the Cardioid Unit.

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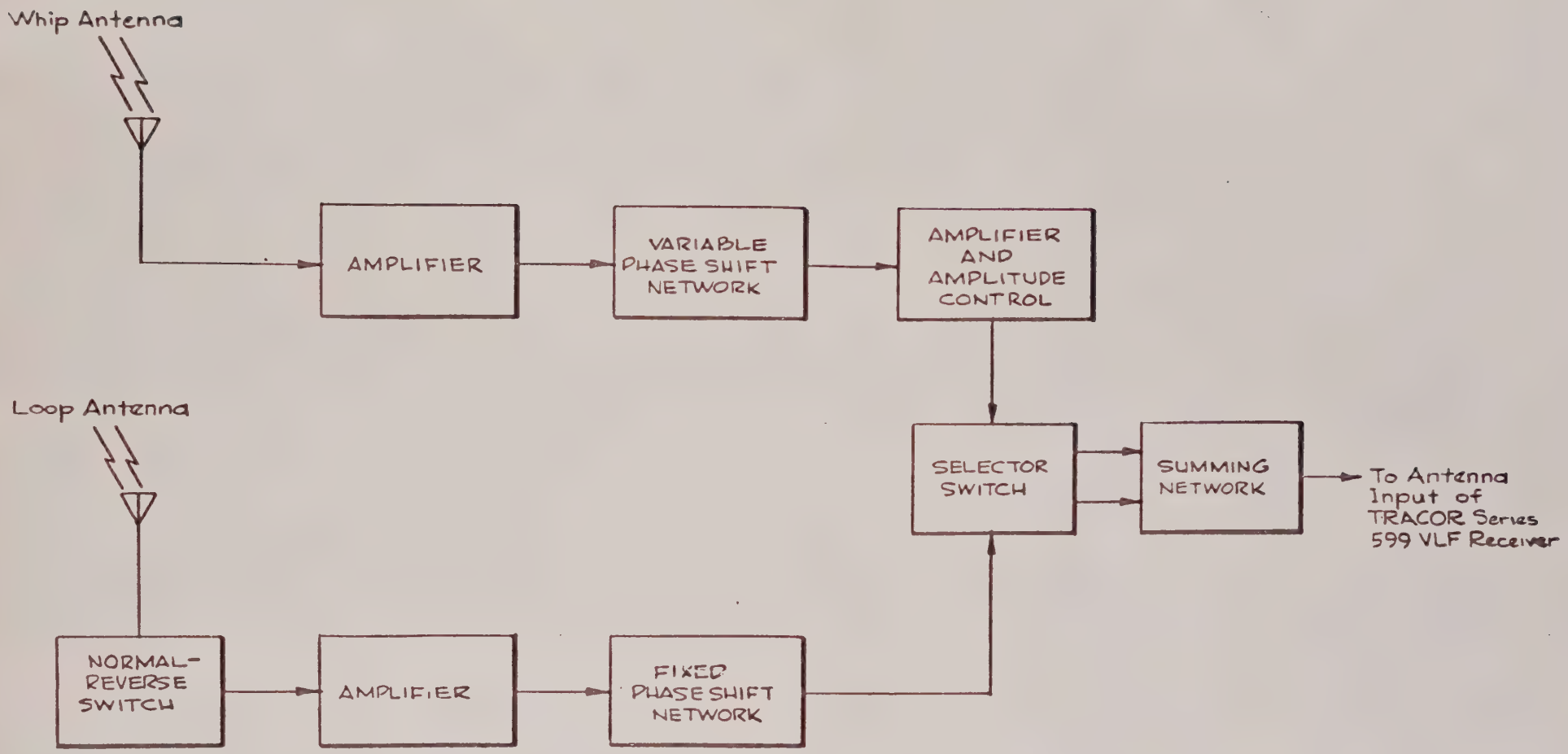
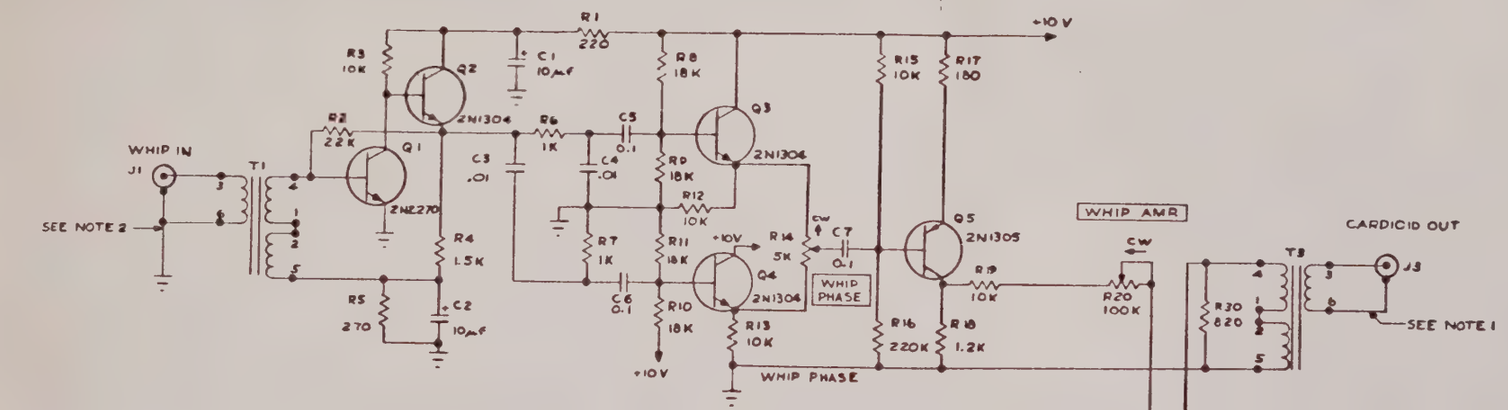
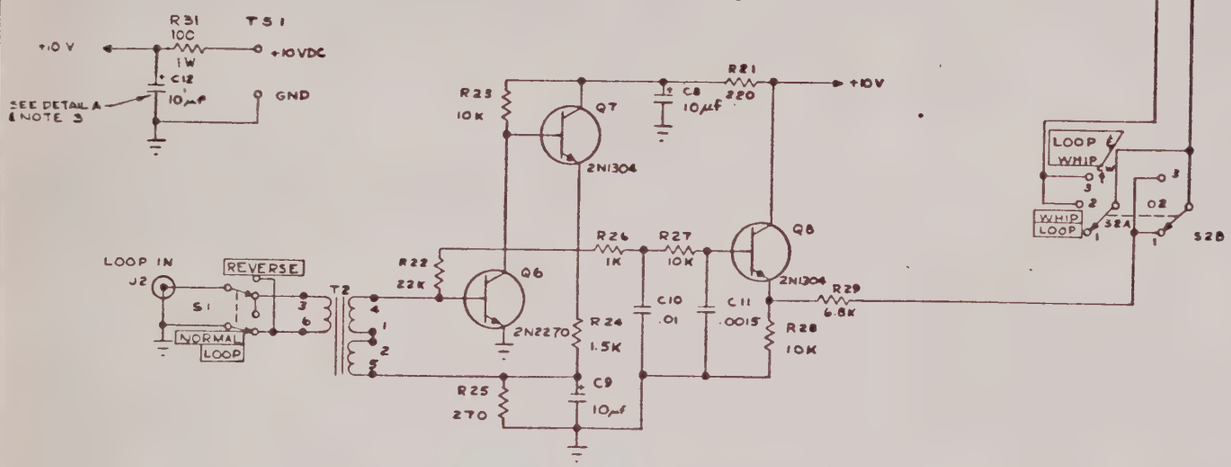


Figure 7-1. Block Diagram, Model 611 Cardioid Unit

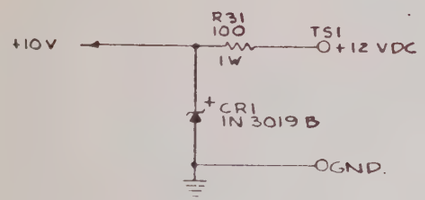
REVISIONS			
ZONE LTR	DESCRIPTION	DATE	APPROVED
X1	RELEASED	11-23-64	ADO
A	GS SYMBOL CORRECTED. E.C. 225	2-4-65	ADO





NOTES:

1. BNC CONNECTOR IS NOT CONNECTED TO CHASSIS; IT IS MOUNTED ON AN INSULATING BOARD.
2. INPUT BNC CONNECTORS SHOULD BE CONNECTED WITH A GROUNDING BUS TO GROUND ON TS1.
3. C12 IS REPLACED BY CR1 WHEN UNIT IS OPERATED FROM A 12-VOLT BATTERY INSTEAD OF FROM 599 SERIES RCVR +10 VOLT SUPPLY.
   C12 IS CONSIDERED STANDARD; CR1 IS KNOWN AS MOD. 71-9.



DETAIL A

Fig 7-2

NEXT ASSY	USED ON		
APPLICATION			

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
DO NOT SCALE DRAWINGS

TOLERANCES		
DECIMALS	FRACTIONS	ANGLES

MATERIAL

ENGINEER		
CHECKED		
SHEET MFR		

TRACOR, INC. AUSTIN, TEXAS

DIAGRAM, SCHEMATIC
CARDOID UNIT, MODEL 611

SIZE	CODE IDENT		
	NO	725019	A
SCALE		SHEET	OF

SWITCH POSITION	NOMINAL FREQUENCY	OPTIMUM STATION
1	BROAD BAND	—
2	160 KC	GBR
3	180 KC	—
4	186 KC	—
5	19 8/20.0 KC	WWVL
6	22.3KC	—

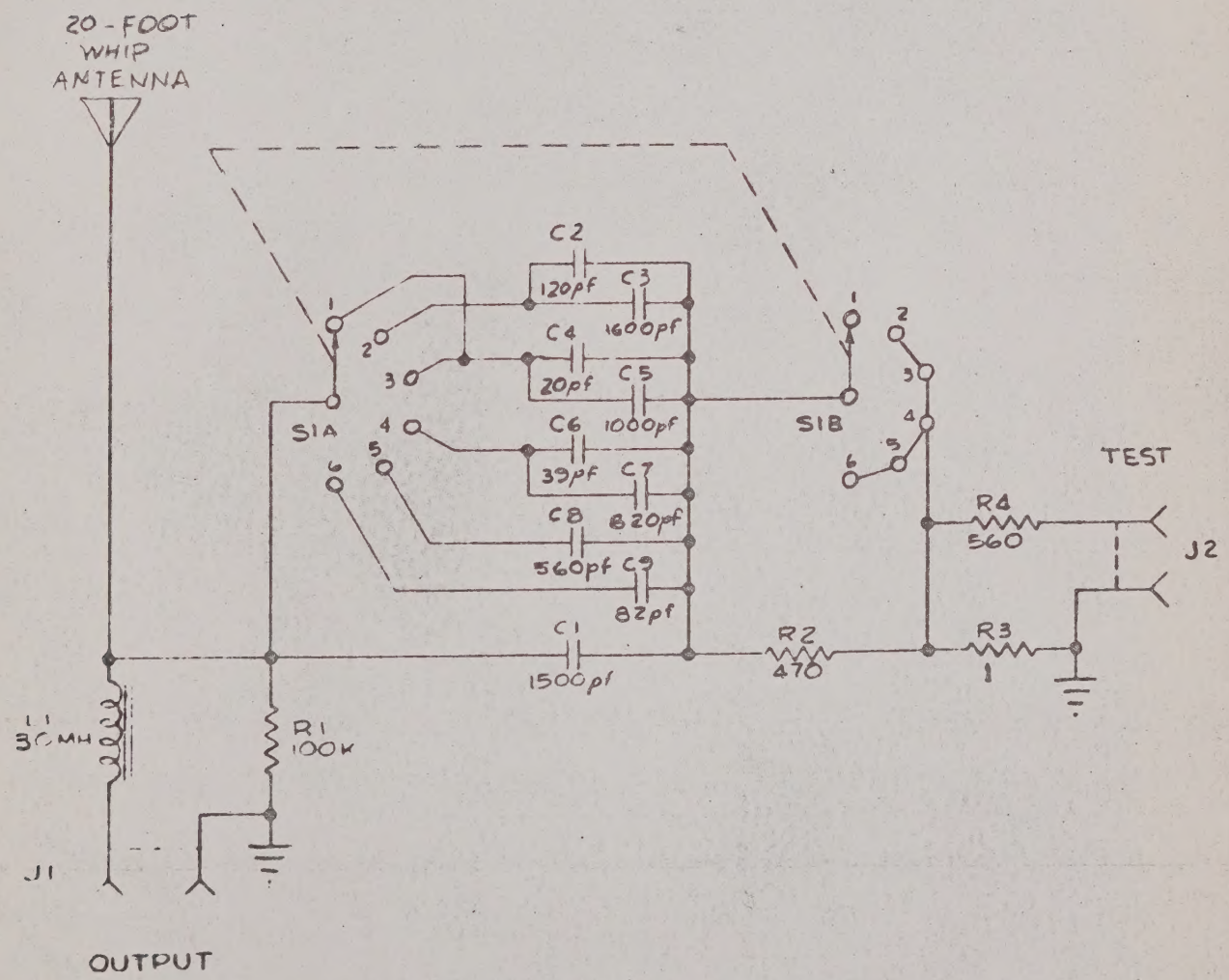


Figure 7-3. Whip Antenna Schematic